

Report for 2004GU31B: Persistent Contaminant Assessment of Food Fish from Tanapag Lagoon, Saipan

There are no reported publications resulting from this project.

Report Follows

Project Title: Persistent Contaminant Assessment of Food Fish from Tanapag Lagoon, Saipan

Problem and Research Objectives

Tanapag Lagoon, on the western shore of central Saipan, harbors a rich diversity of marine life and supports a variety of commercial and recreational activities. Over the years, increased urban growth and commercial developments along the adjacent coastline have resulted in a loss of environmental quality, particularly in the southern half of the lagoon. Primary sources of anthropogenic disturbance in these waters include a power station and commercial port (Saipan Harbor), two small boat marinas, a sewer outfall, several garment factories, auto and boat repair shops, wood shops, government vehicle maintenance yards, a commercial laundry, and an acetylene gas producer. There are also a number of old military dumps and disposal sites in the area as well as a 50-year old municipal dump that served as the island's only solid waste disposal site until its closure a little over two years ago. Several streams and storm drains empty into the lagoon during the rainy season and provide a mode of transport into the ocean for any land-based contaminants. Overflows from sewer lines are also commonplace at this time of the year and the whole area is inundated by storm water runoff during periods of prolonged wet weather. The effects of these perturbations on the indigenous biota within the lagoon are largely unknown. Likewise, fundamental data describing the abundance and distribution of persistent and potentially toxic pollutants within the system is also lacking.

Mindful of these shortcomings, a contaminant assessment of surface sediments within Tanapag Lagoon was recently completed (Denton *et al.* 2001) and a bioindicator survey of the nearshore waters is currently underway. The study reported here examined contaminants of potential concern (mercury, arsenic and PCBs) in important food fishes from within the lagoon and is seen as a logical extension of these studies.

The study focused on dominant species with restricted home ranges as well as those that were more roving in their feeding habits. In so doing the study was able to delineated specific areas of enrichment as well as assess the overall condition of the lagoon from a contamination standpoint. Representative species with different food preferences were selected from various trophic levels in order to evaluate the degrees of biological magnification that have taken place so far for each contaminant. Potential health risks associated with the long-term consumption of edible resources surveyed are also being evaluated

Methodology

Fish were taken from seven sites between Muchot Point at the southern end of the lagoon and Pau-Pau Beach in the north. (Fig. 1). Sites 1-4 are impacted by land-based sources of contamination of one sort or another while sites 5-7 are not and serve as useful reference sites (Table 1). Specimens were caught by local fishermen using hook and line, spear gun and Hawaiian sling. They were chilled immediately and transported to the laboratory in insulated containers. The fish examined during the study are identified in Table 2. The trophic level to which each belongs and their movements within the lagoon are also indicated.

In the laboratory, fish were dissected for analysis using high quality stainless steel instruments. Axial muscle was taken from directly under the dorsal fin on the left side of the fish for mercury and arsenic analysis, and on the right side for PCBs. Where possible, liver tissue was also

removed for heavy metal analysis. Most fish were readily identified and processed within a few hours of capture. Those that weren't were deep-frozen as quickly as possible and processed within one month upon returning to Guam. All tissue samples were stored at -20°C until required for analysis. Those for metal analysis were stored in acid cleaned polypropylene vials while those for PCB analysis were individually wrapped in aluminum foil and sealed in Ziploc® bags.

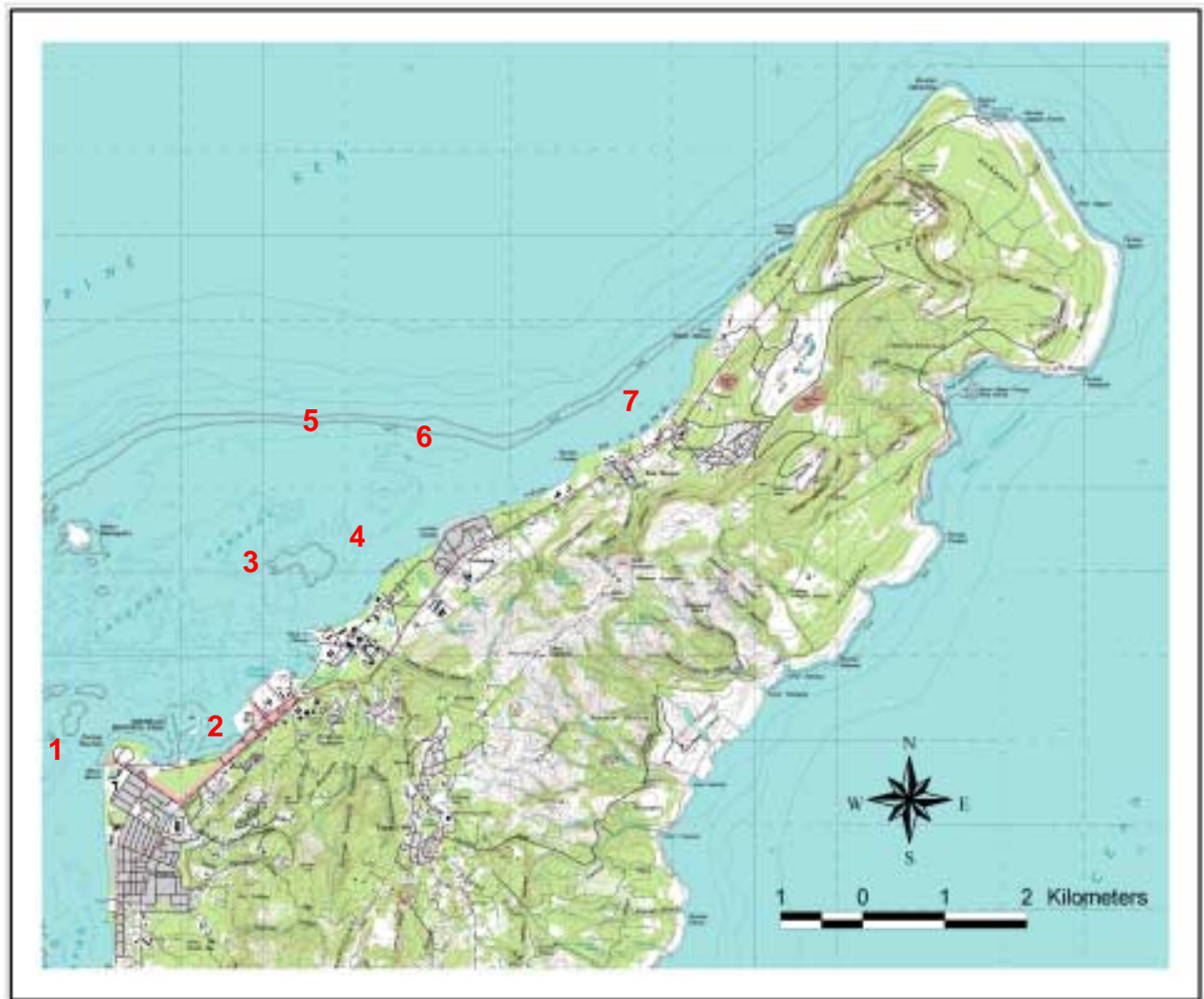


Figure 1: Map of northern Saipan showing fish sampling sites 1-7

To date, all samples have been analyzed for mercury and the arsenic analysis is currently underway. The PCB analysis should be completed within the next 6 months. Analytical protocols for all contaminants of interest are as previously described in Denton *et al.* (1999).

Table 1: Site Identity and Nearby Sources of Heavy Metal and PCB Contamination

Site	Local Name	Nearby Sources of Contamination
1	Micro Beach/Reef	Smiling Cove Marina (metals: boats, antifouling paints)
2	unnamed	Puerto Rico Dump (metals: various, PCBs: transformers)
3	Seaplane Reef	shipping lanes, dry docks (metals: boats, antifouling paints)
4	Tanapag Shoals	PCBs: old transformer storage site in Tanapag village
5	unnamed	none
6	Dankulo Rock	none
7	Pau-Pau Shoals	none

Table 2: Fish Sampled During the Present Survey

Species	Trophic Level*	Micro Beach/Reef	Puerto Rico Dump (seaward edge)	Seaplane Reef	Outer Lagoon Site 1	Outer Lagoon Site 2 (Dankulo Rock)	Tanapag Shoals	Pau-Pau Shoals
<i>Acanthurus blochii</i>	H,DI,R							
<i>Acanthurus lineatus</i>	H, DI, S	22		12		3		2
<i>Acanthurus nigricans</i>	H, DI, R	1					1	
<i>Acanthurus nigricauda</i>	H, DI, R		1				1	
<i>Acanthurus nigrofuscus</i>	H, DI, S		2		1			
<i>Acanthurus olivaceus</i>	O, DI, R					1		
<i>Acanthurus triostegus</i>	H/P, DI, R					1		1
<i>Balistiodes viridescens</i>	C, DI, S		1					
<i>Calotomus carolinus</i>	H, DI, R	2		1				
<i>Caranx melampygus</i>	C, DI, R			2				
<i>Chaetodon ornatissimus</i>	C, DI, S			1				
<i>Cheilinus chlorous</i>	C, DI, R					1		
<i>Cheilinus trilobatus</i>	C, DI, R			2	1		1	
<i>Cheilo inermis</i>	C, DI, R					1		
<i>Chlorurus frontalis</i>	H, DI, R					1		
<i>Chlorurus sordidus</i>	H, DI, R					4	3	
<i>Coris aygula</i>	C, DI, R			1				
<i>Ctenochaetus striatus</i>	H, DI, S	1				2	4	1
<i>Epinephelus maculatus</i>	C, DI, S					1		
<i>Epinephelus howlandi</i>	C, DI, S			2				
<i>Epinephelus merra</i>	C, DI, S			1		1		
<i>Gnathodentex aurolineatus</i>	C, NO, R	1				1	1	1
<i>Halichoeres trimaculatus</i>	C, DI, R					1		
<i>Hemigymnus melapterus</i>	C, DI, R				2			
<i>Heteropriacanthus cruentatus</i>	C, NO, S	1						
<i>Kyphosus biggibus</i>	H, DI, R					1		

Table 2: Fish Sampled During the Present Survey (cont.)

Species	Trophic Level*	Micro Beach/Reef	Puerto Rico Dump (seaward edge)	Seaplane Reef	Outer Lagoon Site 1	Outer Lagoon Site 2 (Dankulo Rock)	Tanapag Shoals	Pau-Pau Shoals
<i>Lethrinus atkinsoni</i>	C, NO, R	2				1		
<i>Lethrinus erythracanthus</i>	C, NO, R					1		
<i>Lethrinus harak</i>	C, NO, R	10	3	5			4	1
<i>Lethrinus obsoletus</i>	C, NO, R	1			1			
<i>Lethrinus olivaceus</i>	C, NO, R					2		
<i>Lethrinus xanthochilus</i>	C, NO, R	3				3		2
<i>Lutjanus fulvus</i>	C, NO, R	1				1		
<i>Lutjanus kasmira</i>	C, NO, R			1		1	2	
<i>Lutjanus monostigmus</i>	C, NO, R	1						
<i>Myripristis amaena</i>	P/C, NO, S	2				1		7
<i>Myripristis berndti</i>	P, NO, S	1	10	2		7	2	1
<i>Myripristis kuntee</i>	P/C, NO, S	1						
<i>Myripristis murdjan</i>	P/C, NO, S	1						
<i>Myripristis pralina</i>	P/C, NO, S	2					4	
<i>Myripristis violacea</i>	P/C, NO, S	7	4					8
<i>Naso annulatus</i>	H, DI, R					1		
<i>Naso lituratus</i>	H, DI, R	4	14	15		1	5	15
<i>Naso unicornis</i>	H, DI, R		1		1		1	1
<i>Naso vlamingii</i>	H, DI, S						1	
<i>Neoniphon argenteus</i>	C, NO, S					1		
<i>Neoniphon opercularis</i>	C, NO, S		1					
<i>Neoniphon sammara</i>	C, NO, S	3						3
<i>Parupeneus barberinus</i>	C, DI, R				1		1	2
<i>Parupeneus multifasciatus</i>	C, DI, R	1	2			1		
<i>Plectropomis laevis</i>	C, DI, R						1	
<i>Pseudobalistes fuscus</i>	C, DI, S					2		
<i>Rhinecanthus aculeatus</i>	O, DI, S						4	
<i>Rhinecanthus rectangulus</i>	O, DI, S			1				
<i>Sargocentron spiniferum</i>	C, NO, S		1	1		1		6
<i>Scarus ghobban</i>	H, DI, R	1		2	3			
<i>Scarus globiceps</i>	H, DI, R				2			
<i>Scarus psittacus</i>	H, DI, R			2		1		
<i>Scarus sp.</i>	H, DI, R			1				
<i>Siganus spinus</i>	H, DI, R		1				1	1
<i>Sphyaena flavicauda</i>	C, DI, R			2				
<i>Sufflamen chrysoptera</i>	O, DI, S					1		
<i>Thalassoma trilobatum</i>	C, DI, R					1		
<i>Triaenodon obesus</i>	C, NO, R			1				
<i>Zanclus cornutus</i>	O, DI, R			1				

* H = herbivore benthic; P = planktivore; C = carnivore; O = omnivore; R = roving/large home range; S = sedentary/small home range
NO = nocturnal feeder; DI = diurnal feeder

Principal Findings and Significance

Over 300 fish representing 65 different species were analyzed for mercury during the course of this work. The data are summarized in Table 3 and show strong trophic level dependence. On average, mean mercury concentrations in fish axial muscle were around an order of magnitude higher in carnivores than herbivores. The highest level found was 0.616 $\mu\text{g/g}$ in a specimen of wire-netting cod, *Epinephelus merra*, from Seaplane Reef (site 3). The highest concentration of mercury found in fish liver was 9.131 $\mu\text{g/g}$ in a specimen of soldier fish, *Myripristis berndti*, from the same area.

Mercury levels in sedentary herbivores and carnivores showed distinct inter-site variability with specimens from Micro Beach having significantly higher mean values in their axial muscle compared with specimens from elsewhere in the study area (Table 3). A scatterplot of data sets for the dominant sedentary carnivores, *Myripristis* spp., suggests such difference cannot be fully explained by variations in body weight alone (Fig. 2). The graph is also suggestive of mercury enrichment in the vicinity of the now closed Puerto Rico Dump (site 2), and at Seaplane Reef (site 3). Such enrichment is to be expected given the nature of anthropogenic activities in this part of the lagoon and the general southerly movement of the entrained water masses.

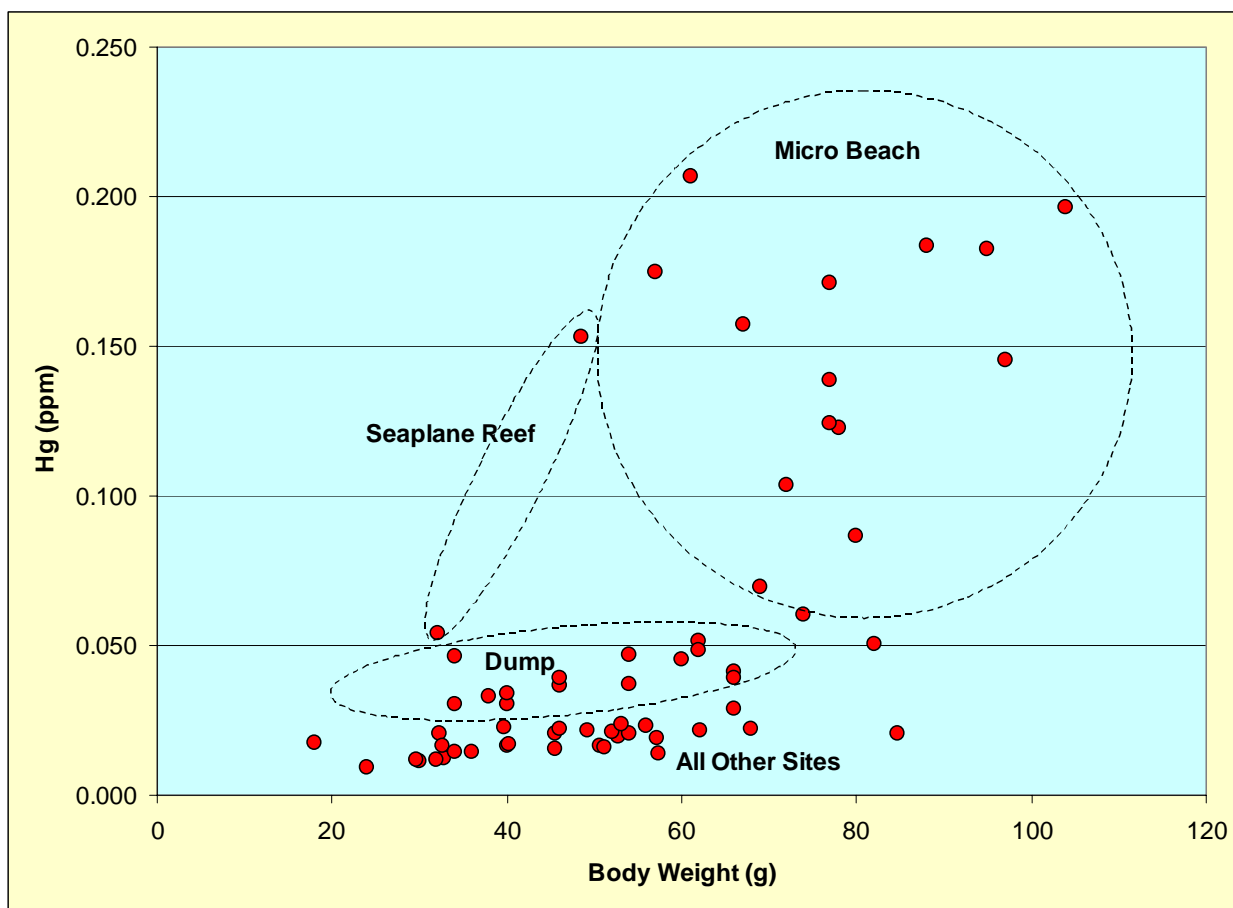


Figure 2: Axial muscle mercury levels vs. wet weight in *Myripristis* spp. from Tanapag Lagoon

Table 3: Mercury in Axial Muscle of Fish from Tanapag Lagoon, Saipan (2003 - 2004)
(all data as µg/g wet weight)

Site	Statistic	Trophic Level*					
		H:S	H:R	C:S	C:R	O:S	O:R
1: Micro Beach/Reef	range	0.004 - 0.109	0.004 - 0.133	0.029 - 0.318	0.010 - 0.212	-	0.017
	median	0.016	0.015	0.161	0.068	-	0.017
	mean	0.019	0.019	0.141	0.078	-	0.017
	# samples	22	9	18	25	-	1
	# species	2	5	8	8	-	1
2: Puerto Rico Dump	range	0.003 - 0.009	0.002 - 0.014	0.030 - 0.297	0.069 - 0.110	-	-
	median	0.006	0.005	0.041	0.079	-	-
	mean	0.006	0.005	0.050	0.085	-	-
	# samples	3	17	17	5	-	-
	# species	2	4	5	2	-	-
3: Seaplane Reef	range	0.003 - 0.114	0.002 - 0.248	0.026 - 0.616	0.016 - 0.396	0.066	0.005
	median	0.005	0.01	0.091	0.084	0.066	0.005
	mean	0.008	0.009	0.097	0.069	0.066	0.005
	# samples	12	21	7	14	1	1
	# species	1	5	5	9	1	1
4: Tanapag Shoals	range	0.002 - 0.010	0.002 - 0.022	0.014 - 0.050	0.010 - 0.161	0.007 - 0.033	-
	median	0.003	0.004	0.018	0.037	0.01	-
	mean	0.003	0.004	0.02	0.04	0.013	-
	# samples	5	12	6	10	4	-
	# species	2	6	2	6	2	-
5: Outer Lagoon Site 1	range	0.007	0.003 - 0.028	-	0.006 - 0.052	-	-
	median	0.007	0.006	-	0.029	-	-
	mean	0.007	0.007	-	0.025	-	-
	# samples	1	6	-	5	-	-
	# species	1	3	-	4	-	-
6: Outer Lagoon Site 2 (Dankulo Rock)	range	0.002 - 0.003	0.001 - 0.006	0.012 - 0.078	0.006 - 0.075	0.018	0.004
	median	0.002	0.002	0.020	0.025	0.018	0.004
	mean	0.002	0.002	0.020	0.024	0.018	0.004
	# samples	5	10	14	12	1	1
	# species	2	7	7	11	1	1
7: Pau-Pau Shoals	range	0.002 - 0.002	0.001 - 0.037	0.009 - 0.063	0.008 - 0.146	-	-
	median	0.002	0.002	0.022	0.018	-	-
	mean	0.002	0.004	0.024	0.022	-	-
	# samples	2	19	27	6	-	-
	# species	1	5	6	4	-	-

* H:S = sedentary herbivore; H:R = roving herbivore; C:S = sedentary carnivore; C:R = roving carnivore; O:S = sedentary omnivore; O:R = roving omnivore; dashes = no data

In non-polluted situations, mercury levels in fish muscle generally lie between 0.001-0.1 µg/g wet weight (Denton and Burdon-Jones 1986) although higher concentrations have been noted in long-lived, predatory species particularly sharks, tuna, marlin and swordfish (Nishigaki *et al.* 1973, Beckett and Freeman 1974, Denton and Breck 1980). In the current study, 86% of all fish examined yielded axial muscle values of less than 0.1 µg/g and 97% had concentrations below 0.2 µg/g. These data suggest that the waters of Tanapag Lagoon are relatively free of mercury pollution. However, one of the problems associated with the current study was that many of the samples analyzed were small, immature individuals as a result of chronic over fishing throughout much of the lagoon in recent years. In all probability, mercury levels are significantly higher in adult fish populations within the region. Nevertheless, the current data are of value because they reflect actual levels currently reaching local consumers who fish these waters on a regular basis. All fish yielding axial muscle mercury levels ≥ 0.1 µg/g are listed in Table 4.

The current FDA food standard for mercury in fish is 1.0 µg/g wet weight, as methylmercury. Methyl mercury is the dominant organic form of mercury in fish and can account for up to 80% of total mercury present (Holden 1973). It is noteworthy, then, that all fish examined during the present study contained methylmercury concentrations that were well below the FDA limit. Unfortunately, this blanket standard does not address variations in consumption rates and so may not adequately protect people living in predominantly fish eating communities like those of the Pacific Islands. The more conservative USEPA risk-based consumption guidelines for methyl mercury in fish are therefore more appropriate here (USEPA 2000). These guidelines are based on an interim RfD of 1×10^{-4} mg/kg/d for a person weighing 70 kg. They take into account the methylmercury levels in the fish consumed and indicate the maximum number of 8 oz fish meals that may be consumed each month. Unrestricted consumption (i.e., more than sixteen 8-oz fish meals per month) is recommended only for fish with methylmercury concentrations of 0.029 µg/g wet weight or less.

If we assume that methylmercury accounts for 80% of total mercury present in edible muscle tissue of species captured during the present survey, then, 92% of all herbivores and 88% of all carnivores (including planktivorous species) were edible in unrestricted quantities. Those that exceeded this value were mostly from the Micro Beach area (58% of the total catch from site 1); adjacent to the dump (43% of total catch from site 2); and at Seaplane Reef (35% of the total catch from site 3). Exceedences of the 0.029 µg/g critical value were only evident in 14-18% of the total catch from each of the remaining four sites.

In accordance with the USEPA guidelines, restricted consumption is warranted for all specimens listed in Table 4. Those with a total mercury concentrations ranging from 0.10-0.15 µg/g, for example, should not be consumed (8 oz portion) more than eight times a month while those with levels >0.15 -0.3µg/g should not be eaten more than four times a month. Figure 3 illustrates the relationship between total mercury concentrations and size in *Lethrinus harak*, one of the more popular table fish locally. This predatory species contained relatively high levels of mercury in its axial muscle and accounted for ~30% of the listings in Table 4. Zones A-D on the graph indicate the size ranges for consumption rates varying from unrestricted (zone A) to no more than eight 8 oz fish meals/month (zone D). Of course, in the absence of definitive methylmercury data for fish from this region, the predicted size ranges can only be regarded as approximations subject to further verification.

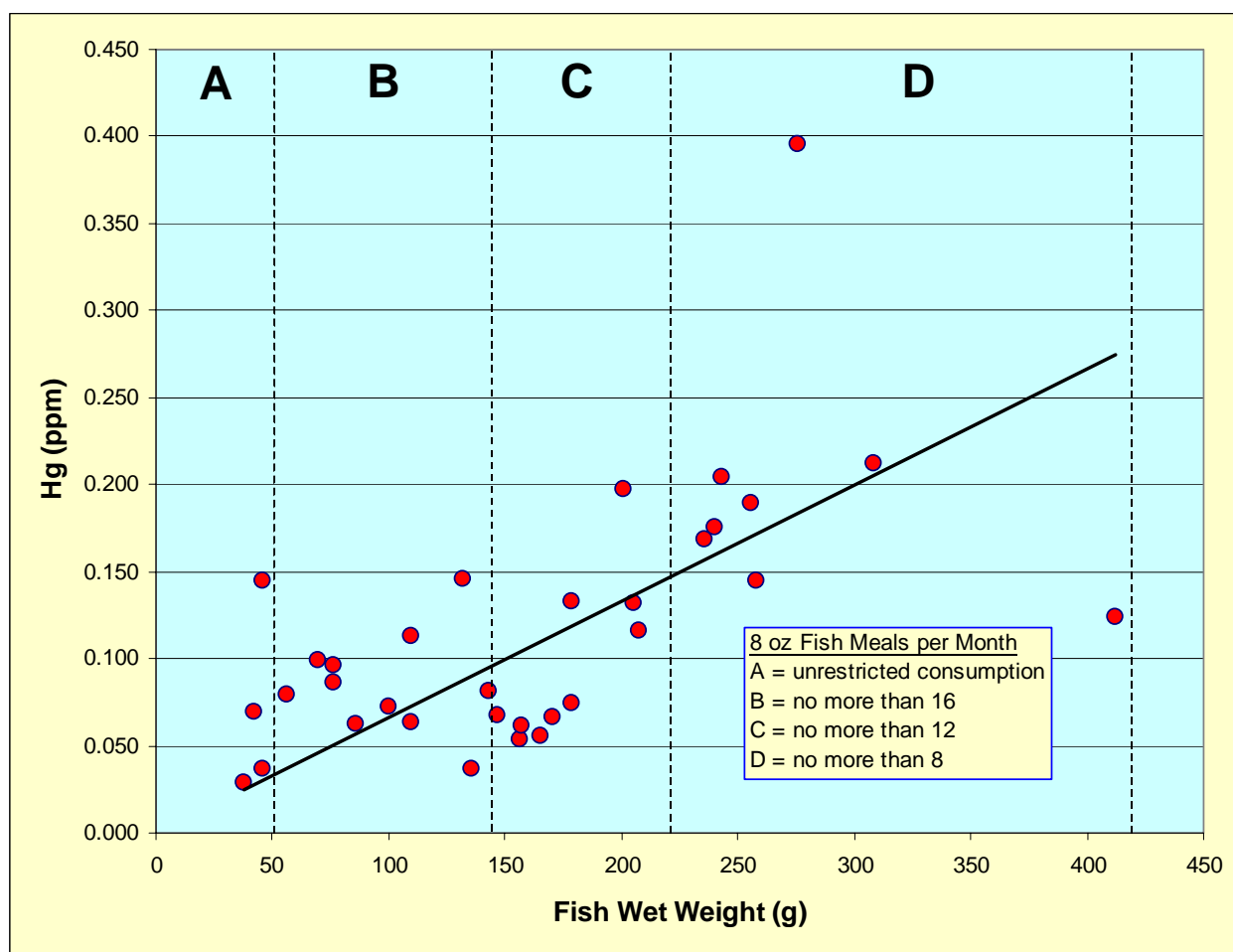


Figure 3: Axial muscle mercury levels vs. wet weight in *Lethrinus harak* from Tanapag Lagoon

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